Journal of Traumatic Stress, Vol. 12, No. 2, 1999

Compelled Attention: The Effects of Viewing Trauma-Related Stimuli on Concurrent Task Performance in Posttraumatic Stress Disorder

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We examined the ability of Vietnam veterans with PTSD to focus attention on a primary digit detection task while concurrently viewing neutral or Vietnam-related picture and word distractors. Controlling for combat exposure, military service, and psychopathology, veterans with PTSD took longer to detect the target when Vietnam-related pictures were distractors. There were no reaction time differences when word stimuli were distractors. The latency effect was specific to trials with trauma-related pictures and did not spread to neutral trials interleaved within a mixed block of trauma and neutral pictures. Individuals with PTSD recalled proportionally more Vietnam-related words than other groups, implying differential attention to Vietnam-related words. Attending to trauma-related pictures interferes with performance of a concurrent task by individuals with PTSD.

KEY WORDS: PTSD; attention; cognition; information processing.

People with anxiety disorders seem biased to process information about threat at the expense of other kinds of information processing (Foa & McNally, 1986; Mathews & MacLeod, 1994). However, the evidence supportive of an attentional bias in PTSD is largely restricted to variations on the modified Stroop task. The only other type of study to investigate the attentional bias in PTSD used a dichotic listening task and failed to find evidence to support the bias hypothesis (Trandel & McNally, 1987). Therefore, it is possible that the apparent attentional biasing

Heidi S. Resnick was the action editor for this manuscript.
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0894-9867/99/0400-0309$16.00/1 © 1999 International Society for Traumatic Stress Studies

effects of trauma-related stimuli in PTSD actually arise only in response to particular kinds of tasks rather than represent an important psychological phenomenon. Additional measures of attentional effects of PTSD are necessary in order to converge on a better understanding of attention in PTSD.

Modified Stroop tasks have been widely employed to study attentional bias in anxiety disorders including simple phobia (Watts, McKena, Sharrock, & Tresize, 1986), social phobia (Hope, Rapee, Heimberg, & Dombeck, 1990), generalized anxiety disorder (Martin, Williams, & Clark, 1991), obsessive-compulsive disorder (Lavy, Oppen, & van Hout, 1994), panic disorder (McNally et al., 1994), and PTSD (Foa, Feske, Murdock, Kozak, & McCarthy, 1991; McNally, Amir, & Lipke, 1996). The results appear to indicate an attentional bias in PTSD patients such that trauma- and threat-related words cause interference in color naming. However, there are a number of issues and discrepancies among extant studies that challenge this conclusion. First, with the exception of Litz et al.'s (1996) report, studies have not included participants with Axis I diagnoses other than PTSD to control for the effect of psychiatric status. The results of Litz et al.'s (1996) study indicate that psychiatric patients performed similarly to the PTSD group on the standard Stroop task. Thus, the Stroop effects could be due, at least in part, to psychiatric status. Second, several investigators report that PTSD patients name the color of all types of words more slowly than control participants (Cassiday, McNally, & Zeitlin, 1992; Kaspi, McNally, & Amir, 1995; Litz et al., 1996; McNally et al., 1996; Vrana, Roodman, & Beckman, 1995). Therefore, the Stroop effect in PTSD may be due in part to a generalized deficit, rather than to interference by specific classes of stimuli.

Despite the popularity of the modified Stroop task in both applied and basic research, inferences from it are limited by the complexity of the task and the mechanisms apparently involved. The Stroop task seems to conflate attentional processes with articulation processes. Because the color of the word and its semantic content are presented in the same location, the Stroop task insures that people attend to the locus of the stimulus. However, the task requires the person to inhibit attention to reading the word *and* to control speech articulation to either say the word or name its color. Thus, slowed color naming times could reflect attentional biases but they may also reflect interference with articulation of the utterance. The connection between reading and speaking may be so automatic (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977) that the increased latency comes from inhibiting the articulation of speech rather than from an inability to attend to the stimuli. Moreover, in the Stroop task, the target (the color) and the distractor (the printed word) are presented in exactly the same location so it is impossible to gaze at one without simultaneously focusing on the other.

Because of these limitations of the Stroop task, better understanding of the impact of PTSD on attentional processes would benefit from examination using a broader range of tasks and measures. Individuals suffering from PTSD often report

difficulty in attending to every-day tasks in the presence of stimuli that remind them of their traumatic experience. These symptoms imply that the attentional effects of PTSD are largely due to an inability to shift attention from a trauma-related stimulus to a more neutral one. In the Stroop task, however, the participant cannot shift attention from the distractor without simultaneously shifting attention from the target stimulus. The word and its color are integral stimuli (Garner 1970) and cannot be separated; removing the ink color necessarily also removes the word so it is difficult to attend to one rather than the other in the sense of controlling input of one aspect versus another. Attention in the Stroop task must come after the words have been perceived.

In the present study, we used a task that separates the target and distractor stimuli spatially and temporally so that we could examine the ability of the individual to disengage from viewing trauma-related stimuli and engage a neutral target stimulus required to complete a task. We presented neutral and trauma-related stimuli on a projection screen and asked the participants to attend to these distractor stimuli. A few seconds later, we added a white digit string to one of the four quadrants of the scene and measured the latency of the individual to detect the presence or absence of a specific digit in that string. Attention to the distractor stimulus competed with attention to the digit strings so we were able to obtain measures of attention to the distractor stimulus (later recognition and recall measures) as well as measures of attention to the primary digit-detection task (response latency). We describe the inability to disengage attention from the distractor stimulus and apply it to the target stimulus as *compelled attention*. In patients, this effect would correspond to an inability to disengage from trauma-related stimuli in favor of environmental stimuli more pertinent to ongoing daily activities.

Another limitation of the Stroop task is that it uses only word stimuli. Because people with PTSD usually report that visual stimuli are a key source of interference, this study examined these attentional effects with picture stimuli as well as with words. Moreover, pictures provide converging evidence concerning the nature of attentional control. Finally, an important question regarding attentional deficits in PTSD which is addressed concerns whether the biasing effect of trauma-related stimuli are specific to a trial in which trauma-specific stimuli are presented or are sufficiently disruptive of attention to carry over to interleaved presentations of non-trauma-related neutral stimuli.

Method

Participants

Seventy-nine male Vietnam era veterans participated. Patients were solicited from the Honolulu VA Mental Health Clinic, Vet Centers, and VA Outpatient

Clinic. Patient participants were recruited from multiple VA clinics to reduce potential research participant biases (Kazdin, 1992). Nonpatient controls were recruited through veterans' groups, community agencies, and through a newspaper article describing the study. See Table 1 for demographic information.

Diagnosis

Participants were diagnosed and placed into experimental groups based on a structured clinical interview. Participants were initially screened using the Combat Exposure Scale (CES; Lund, Foy, Sipprelle, & Strachan, 1984), which is comprised of eight hierarchically arranged items reflecting increasingly more intense combat experiences. The CES has been found to correlate positively with a PTSD diagnosis as well as PTSD symptom intensity (Lund et al., 1984). Participants were interviewed using the Structured Clinical Interview for DSM-III-R, NP, Vietnam form (SCID; Spitzer, Williams, Gibbon, & First, 1989). They also were administered the Mississippi Scale for Combat-Related PTSD (Keane, Caddell, & Taylor, 1988) as a supplementary PTSD diagnostic measure.

The SCID-NP-V (Spitzer et al., 1989) was administered to all participants, by one of three interviewers uninformed as to any prior diagnosis. The interviewers were trained by a representative of the Biometrics Research Department of the New York State Psychiatric Institute, which developed the SCID and coordinated the revision of the DSM-III. Interviewers achieved an agreement rate of at least 90% with the trainer. The SCID was used as the determining measure for assigning a PTSD diagnosis. In addition to the PTSD diagnosis, the SCID was also used to diagnose other psychiatric disorders. To protect against rater drift, a second evaluator reviewed every SCID obtained from the PTSD and Combat control groups. Half of those from the Psychiatric and Vietnam Era control groups were also reviewed.

To provide additional information regarding PTSD symptoms, participants also completed the Mississippi Scale. The Mississippi Scale assesses the symptoms and associated features of PTSD. The higher the score, the more likely the diagnosis of PTSD (Keane et al., 1988). The scores can range from 35 to 175. Keane et al. (1988) reported a sensitivity of .93 and a specificity of .89, and an overall efficiency of .90 in differentiating veterans with and without PTSD using a cutoff score of 107. The Mississippi Scale was also found to be highly correlated with other PTSD diagnostic measures in the landmark National Vietnam Veterans Readjustment Study (Kulka et al., 1990) where a cutoff of 85 was established.

In the three cases where the interviewer had some doubts regarding the SCID PTSD diagnosis, diagnostic consensus conferences were held (see Chemtob, Hamada, Roitblat, & Muraoka, 1994). Two clinicians with extensive experience diagnosing, treating, and studying PTSD (C.M.C. and R.S.H.) met with the interviewer to reach consensus on the presence or absence of a diagnosis of PTSD. The Mississippi scale was then used as a source of supplementary information together with clinical consensus to reach a diagnostic decision.

Table 1. Demographic and Psychometric Data

	PTSD	Combat Control	Psychiatric Control	Noncombat Control
Age	45.81	51.59_a	41.87_b	41.55_b
	(6.89)	(10.20)	(4.14)	(4.59)
Marital status				
Married	38%	70%	44%	65%
	(6)	(19)	(7)	(13)
Separated	38%	4%	6%	0%
	(6)	(1)	(1)	(0)
Divorced	19%	22%	25%	20%
	(3)	(6)	(4)	(4)
Never married	6%	4%	25%	15%
	(1)	(1)	(4)	(3)
Ethnicity				
Asian/Pacific islander	44%	30%	31%	15%
	(7)	(7)	(5)	(3)
African-American	13%	7%	0%	0%
	(2)	(2)	(0)	(0)
Caucasian	38%	67%	69%	85%
	(6)	(18)	(11)	(17)
Hispanic	6%	0%	0%	0%
	(1)	(0)	(0)	(0)
Education				
High school/GED	25%	15%	44%	25%
	(4)	(4)	(7)	(5)
Some college	50%	19%	13%	30%
	(8)	(5)	(2)	(6)
AS	13%	7%	6%	5%
	(2)	(2)	(1)	(1)
BA/BS	6%	26%	25%	25%
	(1)	(7)	(4)	(5)
MA/MS/MBA	0%	30%	13%	15%
	(0)	(8)	(2)	(3)
PhD/MD/JD	6%	4%	0%	0%
	(1)	(1)	(0)	(0)
Branch of service				
Army	69%	63%	56%	30%
	(11)	(17)	(9)	(6)
Navy	0%	11%	25%	45%
	(0)	(3)	(4)	(9)
Air Force	6%	15%	13%	20%
	(1)	(4)	(2)	(4)
Marines	25%	11%	6%	5%
	(4)	(3)	(1)	(1)
PTSD psychometric measures				
Mississippi	108.62_a	59.89_{bc}	80.94_{bd}	58.70_{bc}
	(18.95)	(12.32)	(16.99)	(11.56)
Combat exposure scale	5.00_a	3.96_a	1.00_b	1.00_b
	(1.93)	(1.43)	(0.00)	(0.00)

Note. Numbers in parentheses are standard deviations for the interval-level variables (age, Mississippi, and CES) and frequencies for the nominal variables. Means with different subscripts differ significantly at $p < .013$ by Bonferroni-corrected contrasts.

Inclusion/exclusion criteria. All participants were Vietnam era veterans. Participants were excluded if they met SCID criteria for psychotic disorders because psychosis related alterations of attentional processes may be qualitatively different from those due to other psychopathology (Nelson, Sax, & Strakowski, 1998). Current alcohol or substance abuse/dependence was an exclusionary criterion for all groups because the cognitive effects of alcohol and substance abuse have been shown to persist for some time after cessation of drinking (Eckardt, Stapleton, Rawlings, Davis, & Grodin, 1995). To ensure that PTSD-related cognitive processes would not be confounded with the cognitive effects of alcohol or substance abuse or dependence, we excluded patients who had current (i.e., in the past 30 days) co-morbid alcohol or substance abuse/dependence diagnoses. This limits sample representativeness, and the generalizability of our findings, because veterans with PTSD often have co-morbid alcohol or substance abuse (Davidson, Kudler, Sanders, & Smith, 1990). However, this design advances our understanding of whether PTSD and specific cognitive characteristics are related because failure to exclude co-morbid patients would have confounded alcohol or drug related cognitive changes with those due to PTSD. We also excluded Antisocial Personality Disorder because of diagnostic concerns that this personality disorder can have overlapping features with chronic combat-related PTSD.

Groups

Participant groups were defined and characterized as follows:

Vietnam combat veterans with PTSD (PTSD group). The 16 patients in this group met DSM-III-R criteria for PTSD on the basis of the SCID and scored at least 3 on the CES. They did not meet criteria for thought disorder, organic mental disorder, or antisocial personality disorder. Comorbid diagnoses among these participants included major depression (31%), dysthymia (6%), simple phobia (13%), generalized anxiety disorder (6%), obsessive-compulsive disorder (6%), and adjustment disorder (6%).

Combat control group. This group served as a control for the effects of combat exposure. The 27 participants in this group did not meet criteria for a PTSD diagnosis on the SCID or on the Mississippi Scale. To ensure combat exposure, veterans in this group obtained a score of at least 3 on the CES. They showed no evidence of psychiatric disorder on the mental status exam or the SCID.

Psychiatric control group. This group of psychiatric patients served to control for the generalized effects of psychiatric disorder. The 16 participants met the criteria for a diagnosis other than PTSD or psychotic disorder using the SCID. They were found free of thought disorders. CES score was 1, and Mississippi Scale scores were less than 107. Diagnoses included simple phobia (6%), social phobia (19%), panic disorder (6%), agoraphobia (6%), generalized anxiety disorder (6%), major depression (6%), dysthymia (13%), adjustment disorder (13%),

somatoform disorder (6%), somatization disorder (6%), bipolar disorder (6%), antisocial personality disorder (31%), and personality disorder not otherwise specified (6%). We used a heterogeneous group of psychiatric patients to control for the generalized effects of psychiatric disorder. The alternative strategy of comparing specific diagnostic groups with patients with PTSD would limit generalizability.

Noncombat control group. This group served as a control for the effects of military service, for example those who join the service and for the effects of military training. The 20 participants in this group met all of the criteria of the combat well-adjusted group, but had a CES score of 1. That is, they were not stationed in Vietnam, but served in the military during the Vietnam era, and were not exposed to combat. Using the SCID, they did not meet criteria for any current psychiatric diagnosis.

Informed consent. Our informed consent procedure stated that participation would not affect receipt of services or benefits, nor influence, either positively or negatively compensation claims. Veterans who volunteered to participate were individually given a complete description of the study. All questions were answered before the participant signed the consent form. To protect confidentiality, the study records were kept in a file separate from other VA records.

Apparatus

Stimuli were presented using a two-field rear-projection Gerbrands tachistoscope controlled by a PC-compatible computer. Participants were seated 90 cm from a rear-projection screen in a comfortable chair.

Materials

The stimuli for this experiment were drawn from a list of validated words and pictures (Chemtob et al., 1997). These stimuli were rated by independent panels of participants meeting the criteria for the four groups described above, none of whom served in the present study. The stimuli were rated for unpleasantness, stress, Vietnam relatedness, and memorability. The 30 most Vietnam-related words and the 30 most Vietnam-related pictures were selected from the larger set of Vietnam-related stimuli for presentation. The 50 least Vietnam-related words and the 50 least Vietnam-related pictures were selected from the larger set of neutral stimuli. The Vietnam-related stimuli were demonstrated to be stressful for the PTSD group in the prior study. Examples of the Vietnam-related words include: Ambush, Tet, patrol, fire-fight, VC, hootch, operation, duty. Neutral words included: Skate, robe, ranch, kitchen, carpet, park, worm, and popcorn. See Table 2 for the mean ratings for the stimuli used in the present study.

As projected, the word stimuli were 2 cm tall. The picture stimuli were 10 cm wide by 10 cm tall. The digits consisted of five white 1.0-cm-tall figures displaced 7.5 cm to the left or right and 7.5 cm above or below the middle of the screen.

Table 2. Mean (*SD*) Ratings of Vietnam-Related and Neutral Stimuli

	Vietnam-Related		Neutral	
	Pictures	Words	Pictures	Words
Unpleasantness	5.04 (0.52)	4.73 (0.89)	2.46 (0.34)	2.67 (0.38)
Vietnam-Relatedness	3.48 (0.11)	3.62 (0.27)	2.02 (0.18)	2.20 (0.22)
Stressfulness	4.53 (0.42)	4.22 (0.63)	2.07 (0.22)	2.24 (0.27)
Memorability	4.34 (0.18)	4.55 (0.38)	3.71 (0.44)	3.50 (0.38)

Note. All ratings are on a 7-point scale with 1 being not unpleasant, not Vietnam-related, not stressful and not memorable. A rating of 7 being more unpleasant, Vietnam-related, stressful, and memorable. There were 30 Vietnam-related pictures, 30 Vietnam-related words, and 50 neutral pictures and 50 neutral words.

Procedure

Participants were seen individually in two separate sessions on 2 different days by separate researchers. In the first session, informed consent was obtained, demographic data collected, and the CES, the Mississippi Scale, and the SCID were administered. Participants meeting study criteria were invited back for the second session to take part in the experiment. Session 1 lasted from 1-1/2 to 2-1/2 hr. Participants were paid.

Digit recognition. During the second session, the participants took part in the experiment proper. Each trial presented a pair of stimulus slides. One slide (the target) in each pair consisted of the five digits on a black surround. The other slide in the pair presented a word distractor during the word blocks or a picture distractor during the picture blocks. The distractor and target were presented by separate projectors, equipped with high-speed shutters and a beam splitter, so that they could be independently and precisely timed. When both slides were projected together, the digits appeared as a row of white digits with the distractor as background. The target digits were projected to a randomly selected quadrant of the display to prevent bias to look at only a limited portion of the display. The 160 digit-string slides were randomly generated subject to the constraint that half of the slides contained the target digit (the numeral "4") and half did not. When the target digit was present, it occupied each position in the digit string equally often. Digit strings were randomly paired with the distractors.

Word and picture distractors were presented in separate blocks of trials in order to avoid any contamination of the effects of one stimulus type on the other. Half of the participants were tested on word stimuli first, and half were tested on picture stimuli first. Each block consisted of 80 slide pairs. The first 20 trials in a block presented neutral distractors to obtain a baseline (Neut1). The next 40 trials

presented in mixed order 30 Vietnam-related distractors (VN) intermixed with 10 neutral distractors (Neut2).

Stimuli were blocked in this manner because we wanted to compare the distractor effects that were due to the Vietnam-related stimuli per se versus those due to being in the proximity of Vietnam-related stimuli. There may, for example, be general arousal effects of having seen a Vietnam-related stimulus that would carry over to the neutral stimuli presented in close temporal proximity.

The final set of 20 trials consisted of 20 neutral distractors, again to test for possible carryover effects of the stress produced by Vietnam-related stimuli (Neutpost). This block presented neutral stimuli following the stress-related stimuli and was therefore called Neutral Post Stress or Neutpost. Following this block, participants received a memory test to determine whether the threat-related stimuli yielded greater amounts of incidental learning. The memory test involved free recall following word distractors and picture recognition following picture distractors. Following the memory test, the same sequence of neutral, mixed, and neutral stimuli was presented with the other distractor type.

Four different orders of distractor presentation were used (counterbalanced across participants and diagnostic groups) for each distractor type in order to control for any effects due to differences among the slide characteristics (e.g., slight differences in the Vietnam-relatedness or visual contrast of the neutral stimuli) or interactions between stimulus characteristics and order. Each neutral stimulus occurred equally often in each neutral block, so any differences among blocks could not be due to slight differences in the qualitative features of the stimuli.

Instructions to participants were tape-recorded. They were: "You will hear a 'beep.' Press the button marked with an 'X.' A second or two after pressing the 'X,' a slide will appear on the screen. A few seconds after that, a string of numbers will appear somewhere on the slide. Press the button marked 'Y' if you see the number 4 or press the button marked 'N' if you do not see the 4. Be sure to pay attention to the slides and your reactions to them. Also, put accuracy before speed, that is, try not to make any mistakes, while responding as quickly as you can. We have a practice set of slides to help you understand the task. Do you have any questions?" Ten neutral stimulus slides comprised the practice set.

Each trial began after a 1-s intertrial interval with an acoustic cue that a trial was ready. The participant then initiated a slide presentation with a button press. The distractor slide was presented followed by the presentation of the target slide after a random variable delay averaging 5 s (3.5–6.5 s). The variable delay ensured that participants had the opportunity to look at the distractor slide before presentation of the target (thus providing time for allocation of attention) and the uncertainty made it impossible to anticipate when and where the target would appear. Both target and distractor stimuli remained on the screen until the participant responded by pressing a "Y" or "N" button to indicate detection of the target or its absence. The primary dependent measure was the latency to detect the

presence or absence of a target digit, the number 4, embedded in a string of five digits.

Memory tests. The primary purpose of the memory tests in this experiment was to ensure that the participants were actually viewing the stimuli. The memory test for words was free-recall of all of the words that had been presented in the experiment. Following the digit detection task, participants were asked to remember as many words as possible from the experiment by writing them on a lined sheet; no time limit was imposed on the recall. A recognition test (because recall of pictures was impractical to assess) was used to assess memory for the pictures presented as distractors during the picture phase of the digit detection task. We were primarily interested in the recognition of the Vietnam-related stimuli, but samples of the neutral pictures were also presented. Each participant was given a recording sheet containing 50 lines, one corresponding to each picture presented in the recognition test. A set of 40 Vietnam-related and 10 neutral pictures were presented for recognition. Of the Vietnam-related pictures, 30 were familiar, having been presented during the digit-recognition task and 10 were unfamiliar. All of the neutral pictures were familiar. When we designed the experiment we were interested in using the memory test only to ensure that the participants actually looked at the Vietnam-related pictures. As a result we used both familiar and novel Vietnam-related pictures but used the neutral pictures only to prevent the presentation of 40 Vietnam-related pictures in a row, and any attendant change in the participant's arousal level. This procedure prevented us from assessing the participant's memory for the neutral pictures.

Results

Demographic and Psychometric Group Comparisons

Table 1 provides demographic and psychometric data. The groups differed on percentages of branch of service, $\chi^2(9, N = 79) = 18.68, p < .05$, and marital status, $\chi^2(9, N = 79) = 22.61, p < .01$, but did not differ with respect to education level and ethnicity percentages. These χ^2 values should be interpreted cautiously because they involve comparisons involving cells with small counts.

To evaluate the other differences among the groups, we performed one-way ANOVAs on age and psychometric variables, followed by Bonferroni corrected contrasts (Bonferroni-corrected $p = .05/4 = .013$). The groups were found to differ in age, $F(3, 75) = 9.27, p < .001$. The Combat Control group was older than the Psychiatric Control and Noncombat Control groups, but not older than the PTSD group. As would be expected given our group assignment criteria, the groups differed from each other on Mississippi Scale scores, $F(3, 75) = 46.29, p < .001$. The PTSD group had higher scores than the other three groups, and the Psychiatric Control group had higher scores than the Combat Control and Noncombat Control

groups. Finally, the groups were found to differ on combat exposure, $F(3, 75) = 85.69, p < .001$. The PTSD and Combat Control groups both had higher combat exposure than the other two groups, but did not differ from each other.

Digit Detection Latencies

The main dependent variable in this experiment is the latency to detect or reject the digit. Error rates were extremely low, averaging 1%. There were no differences among groups in the proportion of errors made. As a result, all responses were used to compute the mean response latency. One response latency was computed for each participant for each of four slide types. Slide type 1 (NEUT1) consisted of the mean of the 20 neutral stimuli presented at the start of the experimental block. Slide type 2 (NEUT2) consisted of the mean of the 10 neutral stimuli presented intermixed with the Vietnam-related stimuli. Slide type 3 (VN) consisted of the mean of the 30 Vietnam-related slides presented in the mixed block. Slide type 4 (NEUTPOST) consisted of the mean of the 20 neutral slides presented at the end of the experimental block following the neutral and Vietnam-related stimuli.

Latency data were subjected to mixed-model ANOVAs with Groups as the between-participants factor and Type (i.e., NEUT1, NEUT2, VN, AND NEUTPOST) as the within-participants factor. Effects involving within-participants factors were adjusted by the Greenhouse-Geisser correction. The first set of analyses examined the performance of the three control (i.e., non-PTSD) groups to see whether or not veterans in these groups differed in response latencies. The results of these analyses showed that there were no significant Group or Group X Type interaction for both words and pictures. These results allowed us to perform planned comparisons involving PTSD versus the mean of all three control groups. In the following, all between groups comparisons are planned comparisons between the PTSD group and the mean of the three control groups using the overall error term.

Words. The pattern of results for words is shown in Figure 1. The groups did not differ in mean response latency. Latencies to the different types of words did differ significantly, $F(3, 228) = 4.59, p < .05$. There was no interaction between groups and word type, indicating the pattern of changes in latencies over word types was the same for all four groups. Planned contrasts showed that the latency to NEUT1 was longer than the latency to the other three blocks: NEUT2, $F(1, 75) = 5.89, p < .05$; VN, $F(1, 75) = 6.87, p < .05$; and NEUTPOST, $F(1, 75) = 5.27, p < .05$. There were no other significant differences among word types.

Pictures. The pattern of results for pictures is shown in Figure 2. The groups differed in mean response latency, $F(3, 75) = 3.45, p < .05$. There were no significant differences in response latency to the different picture types. More importantly, however, there was a significant Group X Type interaction, $F(9, 228) = 2.24, p < .05$, suggesting that the pattern of responses to the picture types was

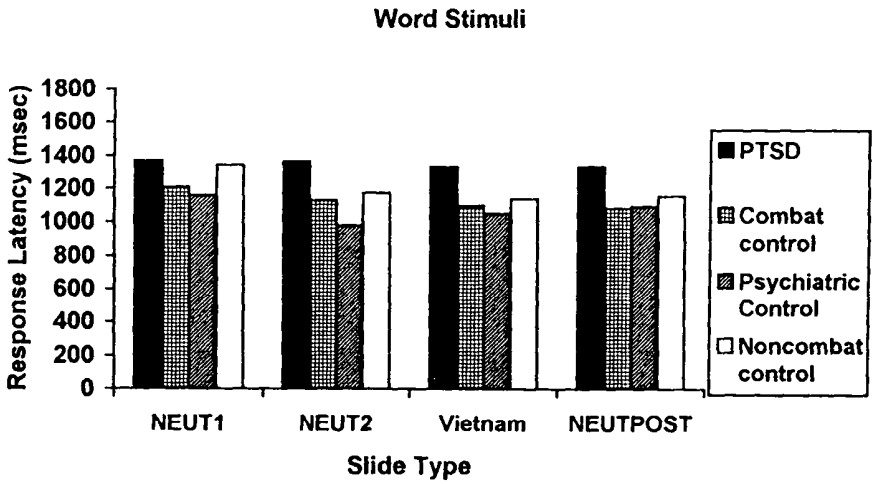

Fig. 1. The response latency to detect the digit "4" in the context of four types of word interference. Neut1 = First neutral block. Neut2 = Neutral words presented among the Vietnam-related words. Vietnam = Vietnam-related words. Neutpost = Neutral words presented after the block of Vietnam-related and neutral words.

different for the PTSD group than for the other groups. This difference was consistent with the results of planned contrasts. Veterans in the PTSD group had significantly longer response latencies to the Vietnam-related pictures, $F(1, 75) = 11.26, p < .01$, relative to the mean of the other groups. The PTSD group's latencies to respond to the Vietnam-related pictures were also longer than their latencies to each of the neutral picture types: VN versus NEUT1, $F(1, 75) = 8.29, p < .01$, VN

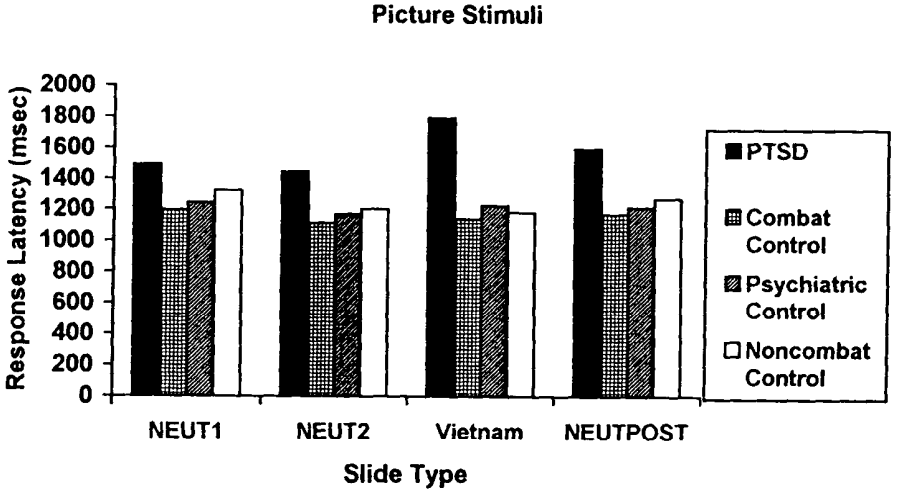

Fig. 2. The response latency to detect the digit "4" in the context of four types of picture interference. Neut1 = First neutral block. Neut2 = Neutral pictures presented among the Vietnam-related pictures. Vietnam = Vietnam-related pictures. Neutpost = Neutral pictures presented after the block of Vietnam-related and neutral pictures.

versus NEUT2, $F(1, 75) = 10.86, p < .01$, VN versus NEUTPOST, $F(1, 75) = 5.38, p < .05$. There were no other significant differences among the groups and types of picture.

We also examined the latencies to the individual Vietnam-related pictures to see if there was a trend toward increasing latency with multiple successive exposures of Vietnam-related pictures. Such a trend could result if Vietnam-related pictures were to produce a cumulative deficit that builds up with successive presentations of trauma-related stimuli (e.g., generalized arousal). Latencies did not increase over the course of the Vietnam-related picture presentations. The PTSD group took longer to respond than did the other groups, $F(3, 75) = 3.93, p < .05$. There was no evidence, however, that the groups showed different latency patterns to sequential presentation Vietnam-related pictures (there was no picture by group interaction), that response latency increased as a function of picture serial positions (linear trend), or of an interaction between the trend and groups.

Picture Recognition

Slide recognition accuracies show that the participants were attending to the distractor stimuli. We examined the percentage of correct recognition for all pictures and separately for Vietnam-related and neutral pictures. There were no differences among groups in the percentage of pictures correctly recognized (as being familiar or novel). The mean proportion of correct recognition for the four groups for Vietnam-related pictures were 0.83, 0.83, 0.78, 0.84 for the PTSD, Combat, Psych, and Era groups respectively. For the neutral stimuli, the mean proportions of pictures correctly recognized were 0.77, 0.86, 0.76, and 0.89, for the PTSD, Combat, Psych, and Era groups, respectively. The recognition task was designed only to evaluate whether participants were attending to the distractors. Limitations in the number of validated stimuli prevented us from using a more sensitive measure of the effects on memory of individual types.

Word Recall

To evaluate whether there was a bias to produce or avoid Vietnam-related words, we computed the proportion of Vietnam-related words produced relative to the number of all of words produced (correct and incorrect). These ratios were computed as a control for possible differences in the propensity to produce words.

Unfortunately, only 76 participants completed the word-recall phase of the experiment. The base rate of incorrectly recalled words was very low (approximately 5%) and did not differ across groups. The groups differed significantly, $F(3, 72) = 4.17, p < .01$ on their recall ratios. Bonferroni-corrected contrasts indicated that the mean recall ratio (0.71) was higher for the PTSD group when compared to each of the other three groups (Ms = 0.58, 0.57, and 0.57 for the

Combat, Psychiatric, and Noncombat Control groups respectively; Bonferroni-corrected $p = .05/4 = .013$). This difference indicates a greater tendency for the PTSD group to recall Vietnam-related words.

A related way to evaluate the word recall effect was to consider whether participants began the sequence of words they recalled with a trauma-related word or a neutral word. Presumably recalling a Vietnam word first in a string of words recalled would reflect a form of attentional bias and less avoidance than remembering a neutral word first. We therefore classified each participant with respect to the type of word produced first during the free recall. Participants with PTSD were more likely to produce a Vietnam-related word as the first word they recalled than the other groups, $\chi^2(3, N = 76) = 11.38, p < .01$.

Discussion

Patients with combat-related PTSD often report that reminders of the trauma interfere with attending to the requirements of every-day tasks. They report subjectively feeling compelled to attend to trauma reminders, so much so that they cannot attend fully to other events. We sought to investigate this subjective complaint in the laboratory using separable compound stimuli. We exposed our participants to stimuli that were either trauma-related or neutral and investigated the extent to which interaction with these stimuli captured the individual's attention and slowed his response to a competing task involving a neutral target. Individuals with PTSD were slowed in their response to the competing target task when they were distracted by trauma-related pictures, but not when the distractor was itself neutral.

We did not find a similar effect when word stimuli were used as distractors. Individuals with PTSD were no poorer at detecting target digits in the presence of trauma-related words than they were in the presence of neutral words. We can only speculate on the differences between word and picture stimuli. We suspect that the difference has to do with the amount of "information" available in words and pictures and the speed with which that information can be extracted. The viewing time for words can be as short as a quarter of a second (Just & Carpenter, 1980) in order to fully read the word. In contrast, additional information seems to be obtained from pictures even after viewing times of several minutes (Yarbus, 1967). Alternatively, pictures may simply convey emotional information more powerfully than words. Further research will be needed to evaluate this finding.

It should also be noted that the failure to find a response latency effect with the word stimuli is consistent with our analysis of the Stroop task as reflecting response conflicts, rather than indicating perceptual attention deficits in that the participants were not required to explicitly respond to the word stimuli.

The experiment included a block of trials in which the distractors were intermixed, that is, some of the distractors were trauma-related and some were neutral.

Although the PTSD group showed higher digit-detection latencies in the presence of trauma-related pictures than in the presence of neutral pictures, this difference was restricted to the Vietnam-related distractors themselves; it did not extend to the neutral stimuli presented on temporally contiguous trials. This difference implies that the longer latencies in the presence of trauma-related stimuli were due to the attention-engaging effects of the distractor rather than due to a generalized deficit in attention or information processing capacity. However, it should be noted that we did not evaluate whether any other type of emotional stimuli would have been effective distractors for the PTSD participants. It is, therefore, logically possible that people with PTSD are simply more emotionally responsive than others (but see Williams, Mathews, & MacLeod, 1996).

These trauma-related pictorial stimuli appear to be attention compelling for individuals with PTSD. That is, these results imply that it is difficult for people with PTSD to disengage their attention from a trauma-related picture stimulus and apply it to a more neutral task stimulus. Also, this effect is specific to trauma-related trials and did not carry over to contiguous trials involving neutral stimuli.

This finding is potentially important in two ways: (a) it suggests that the attentional system in PTSD patients is robustly specific, and (b) it suggests that the Stroop task's effects are not necessarily reflective of a generalized deficit in attentional control. The purported attention-biasing effects of trauma-related words in the Stroop task may be due to increased priming of the trauma-related words making them easier and faster to articulate than other words. As a result, they are more available and more strongly competitive with the color-naming response, thus slowing it. The possibility that Stroop-type interference is due to mechanisms other than differential allocation of attention to trauma-related stimuli receives some support from the findings of Litz et al. (1996). These investigators reported no group differences in latency on the standard Stroop task (naming the ink color of color name words) between PTSD and nonPTSD participants. They did, however, find that the PTSD group was slower at naming the ink color of all threat-related stimuli, not just those specifically trauma related. The modified Stroop results, which reflect the effect of word distractors, may reflect a generalized problem with the articulation of emotional material into speech rather than with attentional control of the features of stimuli. The present findings strongly indicate the need for further analysis of the components of the effects reflected in the modified Stroop task.

These results further suggest that the attentional effects of PTSD are not just a preference or bias to attend to one stimulus or another when alternatives are equally available. Instead, they suggest that the deficit is in disengagement from trauma-related stimuli rather than only in the original allocation of attention to these items. In our experiment, the distractor stimulus preceded the presentation of the target digits on each trial. Therefore, there was no competition for initial attention to the distractor when it appeared. Further, it is unlikely that participants could have known that the Vietnam-related stimuli were Vietnam-related before

they attended to them, so it is unlikely that they could take longer to begin attending to them. It is, nevertheless, logically possible that they might make this decision on the basis of pre-attentive processes.

Two additional assumptions are necessary for this putative difference in allocation of attention to explain the longer latency to attend to Vietnam-related than to neutral stimuli. First, we would have to assume that once participants attend to a picture stimulus, there is some minimum time that they must spend attending to it. Second, we would have to assume that it takes longer to begin attending to Vietnam-related stimuli than to other pictures. Neither of these assumptions seems particularly compelling in part because they predict that Vietnam-related stimuli are both attention repelling (during the initial allocation of attention) and attention compelling (once attended). Rather, it seems much more likely that the difference in latencies for the PTSD group between responding in the presence of the neutral stimuli versus responding in the presence of the Vietnam-related stimuli was a difference in the time necessary to disengage attention—to stop attending to the distractor picture and to start attending to the digits.

In contrast to the effects of the picture distractors, the word distractors had no effect on digit-detection latencies. These results do not indicate, however, that the participants failed to attend to these stimuli. Individuals with PTSD accurately recalled a greater proportion of Vietnam-related words than did the other groups, even when controlling for potential differences in the number of words recalled, independent of type. Their improved memory for these items suggests that they attended to and processed them preferentially.

There were a number of limitations of the current study. Our PTSD participants only included individuals with combat-related PTSD. It is therefore not known whether these findings generalize to PTSD caused by other traumas. We also did not conduct a formal evaluation of reading ability. If we had obtained substantial differences between groups responding to word stimuli these results could have been due to differences in the groups' abilities to read (see Vrana et al., 1995). Higher reading ability might be able to explain better memory for the words that had been presented. In order for reading ability to account for the improved word-memory performance of our PTSD group, we would have to posit that these individuals were actually better readers than the people in the other groups. Familiarity with the Vietnam-related words could also be higher for the PTSD group than for the other groups, but there is no reason to think that familiarity should be related to trauma status rather than to combat exposure, for which we controlled by including a non-PTSD combat exposure group.

In considering these results, it is also important to recognize that this experimental paradigm, like the Stroop, fully confounds attentional and memorial processes. Thus, while PTSD participants appear to have been significantly slowed in redeploying their attention, it is not clear whether this was due to difficulties in controlling the allocation of visual processing resources or to the effort required to

suppress memories elicited by the trauma-related stimuli. Further research along these lines would help to identify the component cognitive processes involved in producing the attentional deficits in PTSD.

The present results have some clinical implications. First, they provide a basis to confirm for patients that the difficulties in attentional control that they report are realistic. Second, increasing our understanding of the component cognitive processes that are responsible for these difficulties, may help refine effective treatment interventions.

Acknowledgment

This research was supported by a VA Medical Research Grant to the first author.

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